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United States
Environmental Protection
Agency

Risk Reduction Engineering Laboratory
Cincinnati, Ohio 45268
Edison, New Jersey 08837

Research and Development

CERI-89-16

EPA

Fifteenth Annual Research Symposium

Remedial Action, Treatment and Disposal of Hazardous Waste

The Westin Hotel
Cincinnati, Ohio
April 10 through April 12, 1989

EP 1.2:

Hotel Map 2
Program 3
Session A Abstracts 13
Session B Abstracts 29
Session A-B Abstracts 45
Session C Abstracts 53

All meeting rooms
have been designated
NC Smoking Room

CERI-89-16
April 1989

Fifteenth Annual Research Symposium

Remedial Action, Treatment and Disposal of Hazardous Waste

Sponsored by:
Risk Reduction Engineering Laboratory
Cincinnati, Ohio 45268
Edison, New Jersey 08837

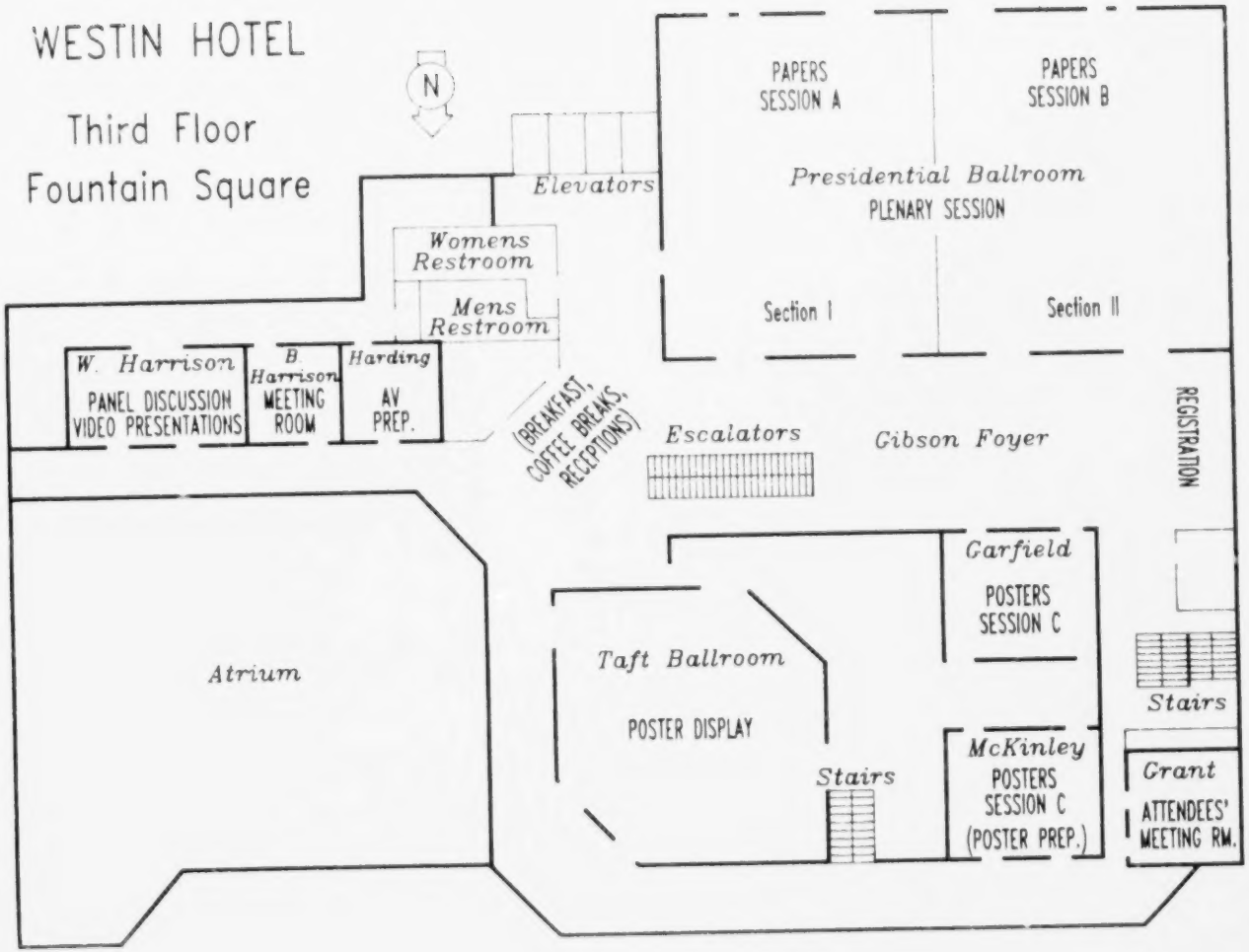
E. Timothy Oppelt, Director

Eugene F. Harris, Project Officer
John A. Glaser, Project Officer
Teri Shearer, Project Officer

Coordinated by:
JACA Corporation
Fort Washington, PA 19034
and
PEI Associates, Inc.
Cincinnati, OH 45246

WESTIN HOTEL

Third Floor
Fountain Square



Registration -- Gibson Foyer
6:00 pm - 8:30 pm - Sunday April 9
7:00 am - Monday April 10

MONDAY, APRIL 10

(Cash Breakfast, 7:30 am to 9:00 am, Gibson Foyer)

PLENARY SESSION

9:00 am	WELCOME REMARKS E. Timothy Oppelt, Director Risk Reduction Engineering Laboratory U.S. Environmental Protection Agency, Cincinnati, OH
9:30 am	SUPERFUND ACTIVITIES Walter Kovalick, Deputy Director Office of Emergency and Remedial Response U.S. Environmental Protection Agency, Washington, DC
10:00 am	COFFEE BREAK
10:30 am	RCRA ACTIVITIES Sylvia Lowrance, Director Office of Solid Waste U.S. Environmental Protection Agency, Washington, DC
11:00 am	ENVIRONMENTAL PROTECTION IN THE 1990s Anthony D. Cortese, Director Center for Environmental Management Tufts University, Medford, MA
11:30 am	Question and Answer Period
12:00 noon	LUNCH (Delmonico's Restaurant - Ticket Holders Only) Poster Displays Open - Taft Ballroom

MONDAY, APRIL 10 (Continued)

	A – PAPERS (Presidential I)	B – PAPERS (Presidential II)	C – POSTERS (Garfield and McKinley)
Session	**1-A Thermal Destruction 1** **Moderator: C.C. Lee** **U.S. EPA, RREL**	**1-B Biotechnology I** **Moderator: Glenn Shaul** **U.S. EPA, RREL**	**1-C Posters**
1:30 pm	**Development and Validation of a Surrogate Metals Mixture** Randy Seeker Energy and Environmental Research Corp. Irvine, CA	**PCB Degradation: Status and Direction** P.R. Sferra U.S. EPA, RREL Cincinnati, OH	**Immobilization Mechanisms in Solidification/Stabilization Using Cement/Silicate Fixing Agents** Marty Tittlebaum Louisiana State University Baton Rouge, LA
2:00 pm	**Incinerating Ethylene Dibromide and Dinoseb Stocks** Donald A. Oberacker U.S. EPA, RREL Cincinnati, OH	**The Development of Recombinant Bacteria for Polychlorinated Biphenyl Degradation** Frank Mondelio General Electric Co. Schenectady, NY	**Waste Reduction Evaluations at Federal Sites** James S.Bridges U.S. EPA, RREL Cincinnati, OH
2:30 pm	**Laboratory Studies of a Hazardous Waste Incinerability Surrogate Mixture** Barry Dellinger University of Dayton Dayton, OH	**Treatment of Wood Preserving Soil Contaminants by White Rot Fungus** John A. Glaser U.S. EPA, RREL Cincinnati, OH	**Demonstrated Computer Assisted Engineering Techniques for Remedial Action Assessment** Phillip R. Cluxton University of Cincinnati Cincinnati, OH
3:00 pm	**COFFEE BREAK**		

Session	2-A Thermal Destruction II Moderator: Donald Oberacker U.S. EPA, RREL	2-B Biotechnology II Moderator: P.R. Sferra U.S. EPA, RREL	2-C Posters
3:30 pm	**Incinerability Ranking for Hazardous Organic Compounds** Robert E. Mournighan U.S. EPA, RREL Cincinnati, OH	**Biological Treatment of Petrochemical Sludges** Stephen Field Louisiana State University Baton Rouge, LA	**Hydraulic Mechanisms of a Multiple Soil Layer Cover** Richard C.Warner University of Kentucky Lexington, KY
4:00 pm	**A Prototype Baghouse/Dilution Tunnel System for Particulate Sampling of Hazardous and Municipal Waste Incinerators** Paul Lemieux U.S. EPA, AEERL Research Triangle Park, NC	**The Determination of Biodegradability and Biodegradation Kinetics of Organic Pollutant Compounds with the Use of Electrolytic Respirometry** Henry H. Tabak U.S. EPA, RREL Cincinnati, OH	**Evaluation of Solidification/ Stabilization Treatability Studies at the U.S. EPA Center Hill Facility** Edwin Barth U.S. EPA, RREL Cincinnati, OH
4:30 pm	**Evaluation of Alternative Treatment Technologies for Hazardous Wastes From Acrylonitrile Production** Ronald Turner U.S. EPA, RREL Cincinnati, OH	**Prediction and Modeling of Biodegradation Kinetics of Hazardous Waste Constituents** Rakesh Govind University of Cincinnati Cincinnati, OH	**The EPA Manual for Waste Minimization Opportunity Assessments** Mary Ann Curran U.S. EPA, RREL Cincinnati, OH

Reception, 5:00 pm, Gibson Foyer (cash bar)
Riverboat Dinner Cruise, 7:00 pm to 9:00 pm (ticket holders only)

TUESDAY, APRIL 11

(Cash Breakfast, 7:00 am to 8:30 am, Gibson Foyer)

	A – PAPERS (Presidential I)	B – PAPERS (Presidential II)	C – POSTERS (Garfield and McKinley)
Session	**3-A Underground Storage Tanks I** **Moderator: Richard A. Griffiths** **U.S. EPA, RREL**	**3-B Biological Treatment** **Moderator: Douglas Grosse** **U.S. EPA, RREL**	**3-C Posters**
8:30 am	**Panel Discussion: The Regulatory Update of Hazardous Waste Thermal Destruction (W. Harrison Room)** **(Speakers: S. Garg, OSW; M. Petruska, OSW; S. Stelmack, OSW; A. Trenholm, MRI)**		
8:30 am	**The Role of Site Characterization in the Selection of Corrective Actions for Leaking Underground Storage Tanks** Myron S. Rosenberg Camp Dresser & McKee, Inc. Boston, MA	**Microbial Treatment of Contaminated Soil Fines** David Kosson Rutgers University Piscataway, NJ	**U.S. EPA Combustion Research Facility** Robert C. Thurnau U.S. EPA, RREL Cincinnati, OH
9:00 am	**Evaluation of the Accuracy of Volumetric Leak Detection Methods for Underground Fuel Storage Tanks Containing Gasoline** Joseph W. Maresca, Jr. Vista Research, Inc. Mountain View, CA	**Fate of RCRA and CERCLA Toxics in Anaerobic Digestion of Primary and Secondary Sludges** Richard A. Dobbs U.S. EPA, RREL Cincinnati, OH	**Evaluating the Cost Effectiveness of SITE Demonstrations** Gordon Evans U.S. EPA, RREL Cincinnati, OH
9:15 am	**Bus Departs Hotel for First Tour of EPA's Center Hill Facility**		
9:30 am	**An Outreach Process: Case Histories of Underground Storage Tank Corrective Actions** Harry Lindenhofen CDM Federal Programs Corp. Fairfax, VA	**Fate and Effects of Selected RCRA and CERCLA Compounds in Activated Sludge Systems** Sanjoy K.Bhattacharya University of Cincinnati Cincinnati, OH	**Simultaneous Hazardous Waste Destruction and Trace Metal Capture in a Fluidized Bed Incinerator** John H. Wasser U.S. EPA, AEERL Research Triangle Park, NC
10:00 am	**COFFEE BREAK**		

Session	**4-A Underground Storage Tanks II** **Moderator: Anthony N. Tafuri** **U.S. EPA, RREL**	**4-B Landfill** **Moderator: David Carson** **U.S. EPA, RREL**	**4-C Posters**
10:30 am	**Considerations of Underground Storage Tank Residuals at Closure** Warren J. Lyman Camp Dresser & McKee, Inc Boston, MA	**Compatibility of Flexible Membrane Liners and Municipal Solid Waste Leachates** Henry Haxo, Jr. Matrecon, Inc. Alameda, CA	**BioTrol Soil Washing System** Steven Valine BioTrol, Inc. Chaska, MN
11:00 am	**Laboratory Studies of Vacuum-Assisted Steam Stripping of Organic Contaminants from Soil** Arthur E. Lord Drexel University Philadelphia, PA	**Geosynthetic Concerns in Landfill Liners and Collection Systems** Robert M. Koerner Drexel University Philadelphia, PA	**Separation of Hazardous Organics by Low Pressure Reverse Osmosis (RO) Membranes** D. Bhattacharyya University of Kentucky Lexington, KY
11:30 am	**Low Temperature Thermal Desorption for Treatment of Contaminated Soils** Richard Lauch U.S. EPA, RREL Cincinnati, OH	**Attenuation of Priority Pollutants Codisposed with MSW in Simulated Landfills** Frederick G. Pohland University of Pittsburgh Pittsburgh, PA	**Testing of a Leachate Treatment System Based on a Wood Degrading Fungus** John A. Glaser U.S. EPA, RREL Cincinnati, OH
12:00 noon	**LUNCH** **(Delmonico's Restaurant - Ticket Holders Only)**		
12:00 noon	**Bus Departs for Cincinnati Bicentennial Commons**		
1:15 pm	**Bus Departs Hotel for First Tour of EPA's T & E Facility**		
Session	**5-A Innovative Techniques I** **Moderator: Walter Grube** **U.S. EPA, RREL**	**5-B SITE/WRITE Session** **Moderator: Norma M. Lewis** **U.S. EPA, RREL**	**5-C Posters**
1:30 pm	**Detection of Macro Defects in Soil-Bentonite Cutoff Walls** Andrew Bodocsi University of Cincinnati Cincinnati, OH	**SITE Demonstration of the Hazcon Process** Paul de Percin U.S. EPA, RREL Cincinnati, OH	**Assessment of KPEG Treatment for PCB Contaminated Soils** Alfred Kornel U.S. EPA, RREL Cincinnati, OH

TUESDAY, APRIL 11 (Continued)

	A - PAPERS (Presidential I)	B - PAPERS (Presidential II)	C - POSTERS (Garfield and McKinley)
2:00 pm	**Innovative Delivery and Recovery Systems: Hydraulic Fracturing** Lawrence C. Murdoch University of Cincinnati Cincinnati, OH	**Results of the SITE Program Demonstration of the Terra Vac In-Situ Vacuum Extraction Technology** Mary K. Stinson U.S. EPA, RREL Edison, NJ	**Methods for Measuring Soil Liner Vac Permeability in the Field** David Anderson K.W. Brown Assoc., Inc. College Station, TX
2:30 pm	**Computer - Based Methods of Assessing Contaminated Sites: Case Histories** William G. Harrar University of Cincinnati Cincinnati, OH	**Overview of the Waste Reduction Innovative Technology Evaluation (WRITE) Program** Michael Szabo PEI Associates, Inc. Cincinnati, OH	**Review of Soil Washing Technologies for Soils Contaminated with Heavy Metals** Carl Gutterman Foster Wheeler Enviresponse, Inc. Edison, NJ
3:00 pm		**COFFEE BREAK**	
Session	**6-A Innovative Techniques II** **Moderator: Ben Blaney** **U.S. EPA, RREL**	**6-B Solidification** **Moderator: Darlene Williams** **U.S. EPA, RREL**	**6-C Posters**
3:30 pm	**Economics of the KPEG Process for Decontamination of PCBs in Soil** D.B. Chan U.S. Navy Port Hueneme, CA	**Solidification/Stabilization as a BDAT for RCRA Wastes** R. Mark Bricka Department of the Army Vicksburg, MS	**Rotary Kiln Incineration** Vic A. Cundy Louisiana State University Baton Rouge, LA
4:00 pm	**Destruction of Cyanides in Electroplating Wastewaters Using Wet Air Oxidation** H. Paul Warner U.S. EPA, RREL Cincinnati, OH	**Volatile Emissions from Stabilized Waste** Leo Weitzman Acurex Corporation Research Triangle Park, NC	**Biological Treatment of Chlorophenol-Contaminated Groundwater** Thomas Chresand BioTrol, Inc. Chaska, MN

4:30 pm	**Cost-Effective Approaches to the Environmental Control of Electroplating Operations** John O. Burckle U.S. EPA, RREL Cincinnati, OH	**Technologies Applicable for the Remediation of Superfund Radiation Sites** Ramjee Raghavan Foster Wheeler Enviresponse, Inc. Edison, NJ	**Computerized Management and Dissemination of Information for Research and Development Operations at the Technical Information Exchange (TIX), Edison, NJ** May Smith Foster Wheeler Enviresponse, Inc. Edison, NJ

Reception, 5:00 pm, Gibson Foyer (cash bar)

WEDNESDAY, APRIL 12

(Cash Breakfast, 7:00 am to 8:30 am, Gibson Foyer)

	A/B – PAPERS (Presidential I)	C – POSTERS (Garfield and McKinley)
Session	**7-A/B Site Remediation I** **Moderator: Joyce M. Perdek** **U.S. EPA, RREL**	**7-C Posters**
8:30 am	**RRELevant QA Diagnostics: Major Findings in FY '88** Ronald D. Hill U.S. EPA, RREL Cincinnati, OH	**Treatability Data Base** Kenneth A. Dostal U.S. EPA, RREL Cincinnati, OH
8:45 am	**Bus Departs Hotel for Second Tour of EPA's Center Hill Facility**	
9:00 am	**Effect of Feed Characteristics on the Performance of EPA's Mobile Incineration System** Gopal Gupta Foster Wheeler Enviresponse, Inc. Edison, NJ	**Chemical Treatment of Metals in Wastewaters and Sludges at the T&E Facility** Douglas Grosse U.S. EPA, RREL Cincinnati, OH
9:30 am	**Long-Term Field Demonstration of the LINDE Oxygen Combustion System at the EPA Mobile Incinerator** Min-Da Ho Union Carbide Corp. Tarrytown, NY	**Biological Degradation of Chlorinated Phenoxyacetates and Phenols** Richard Haugland University of Illinois Chicago, IL
9:45 am	**Bus Departs Hotel for Second Tour of EPA's T & E Facility**	
10:00 am	**COFFEE BREAK**	

Session	8-A/B Site Remediation II Moderator: Michael Roulier U.S. EPA, RREL	8-C Posters
10:30 am	**In Place Treatment of Contaminated Soil at Superfund Sites** Janet Houthoofd U.S. EPA, RREL Cincinnati, OH	**Use of Foam Technology for Control of Toxic Fumes During Excavation at Superfund Sites** Mark Torpey Foster Wheeler Development Corp. Livingston, NJ
11:00 am	**A Claims Avoidance Expert System** Daniel G. Greathouse U.S. EPA, RREL Cincinnati, OH	**Soil Washing -- Removal of Semivolatile Organics via Aqueous Surfactant Solutions** Edward Coles Foster Wheeler Enviresponse, Inc. Edison, NJ
11:30 am	**Assessment of Chemical and Physical Methods for Decontaminating Buildings and Debris at Superfund Sites** Michael L. Taylor PEI Associates, Inc. Cincinnati, OH	**Preparation for SITE Demonstration of a Powdered Activated Carbon Treatment (PACT) Unit** John Martin U.S. EPA, RREL Cincinnati, OH

SESSION A ABSTRACTS

DEVELOPMENT AND VALIDATION OF A SURROGATE METALS MIXTURE

R.G. Barton, W.D. Clark, and W.R. Seeker
Energy and Environmental Research Corporation
Irvine, CA

C.C. Lee
U.S. EPA, RREL
Cincinnati, OH

The U.S. Environmental Protection Agency has developed regulations to control the burning of metal bearing wastes in hazardous waste incinerators. These regulations affect a majority of the incinerators in the U.S., since nearly every waste contains at least trace quantities of some toxic metals. Recent research indicates that metal emissions from incinerators are controlled by a number of parameters, including metal type, incinerator temperature, and waste chlorine content. This makes it difficult to define appropriate permit conditions which will guarantee acceptable emissions of all toxic metals, given the data obtained from current trial burn procedures. A surrogate metals mixture was developed to provide a coherent, defensible method for evaluating the behavior of metals in incinerators. The mixture consists of four surrogate metals whose behavior can be used to predict the behavior of toxic metals. Components of the surrogate metals mixture were selected based on five criteria: volatility, toxicity, abundance, chemical species, and cost.

A test series was planned to verify the appropriateness of using a surrogate mixture and to determine if the metals selected were acceptable. The test program involved spiking a synthetic waste with both the surrogate metals and toxic metals, burning the waste under a variety of operating conditions, and comparing the surrogate metals' behavior with the behavior of the toxic metals.

Some of the validation tests were carried out at the EPA's Combustion Research Facility. The results from these tests were analyzed and the validity of the surrogate metals approach was assessed.

INCINERATING ETHYLENE DIBROMIDE AND DINOSEB STOCKS

Donald A. Oberacker
U.S. EPA, RREL
Cincinnati, OH

Carol Stangel
U.S. EPA, OPP
Washington, DC

Pursuant to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), pesticides for which registrations have been cancelled due to findings of real or suspected adverse effects on human health and the environment can no longer be marketed and used for their intended purpose. In a number of cases to date, the Environmental Protection Agency (EPA) has had to first purchase and safely store and dispose of existing stocks of the concentrated or formulated products. Although recent FIFRA amendments will shift some of this financial burden to the manufacturers, EPA anticipates playing a continuing major role by supervising the storage and disposal of pesticides cancelled in the future.

This paper summarizes EPA's progress in the proper destruction of two pesticide inventories, ethylene dibromide (EDB) and dinoseb, at commercial hazardous waste incineration facilities. Over 300,000 gallons of EDB were incinerated during 1988 using a special technique that prevented the release of bromine to the atmosphere. EPA is currently initiating a similar action that will result in the incineration of two to four million gallons of dinoseb, where the major concern is the potential for NOx generation due to the nitrogen content of dinoseb.

The pesticide characteristics, disposal options considered for treatment and disposal, pilot- or full-scale testing, the incineration method ultimately selected, and incinerator performance testing results are also addressed in this paper.

LABORATORY STUDIES OF A HAZARDOUS WASTE INCINERABILITY SURROGATE MIXTURE

Barry Dellinger, Debra A. Tirey, and Philip H. Taylor
University of Dayton Research Institute
Dayton, OH

C.C. Lee
U.S. EPA, RREL
Cincinnati, OH

The complexity of determining the efficiency of hazardous waste incinerators for destruction of toxic materials has led to numerous proposals for testing and certification procedures. Several stability indices for the principal organic hazardous constituents (POHCs) of the waste have been proposed. Studies of the formulation of Products of Incomplete Combustion (PICs) have led to concern over PIC emissions and the need for emissions screening.

In an effort to circumvent many of the uncertainties in existing approaches, we have proposed a simple mixture of compounds which may be used as a standardized incinerator test mixture. This proposed mixture contains stable POHCs which also produce stable PICs that can be used as surrogates for testing the incinerability of most hazardous waste streams. The proposed mixture of acetonitrile, chlorobenzene, pentachlorobenzene, sulfur hexafluoride, tetrachloroethene, trifluorochloromethane, and toluene was developed to address all potential incinerator failure modes. Laboratory investigation of the pyrolysis of the mixture in a flow reactor system shows that the mixture is indeed stable, and produces a significant yield of stable PICs. Ramifications of this study on incineration test procedures are briefly discussed.

INCINERABILITY RANKING FOR HAZARDOUS ORGANIC COMPOUNDS

Robert E. Mournighan, Robert C. Thurnau, Gregory J. Carroll, Marta K. Richards, and Howard O. Wall
U.S. EPA, RREL
Cincinnati, OH

Since EPA became involved with the regulation and permitting of hazardous waste incinerators, developing a reliable measure of incinerator performance has been one of its goals. The use of a thermal stability index to rank Principal Organic Hazardous Constituents (POHCs) has facilitated the evaluation of incinerators. The development of data to support the thermal stability rankings has been an ongoing effort.

This paper discusses the results of a parametric study in which temperature and oxygen concentrations were evaluated relative to destruction and removal efficiency (DRE) of the test mixture. The compounds used in the text mixture were: toluene, chlorobenzene, tetrachloroethylene, tetrachlorobenzene, and sulfur hexafluoride.

A PROTOTYPE BAGHOUSE/DILUTION TUNNEL SYSTEM FOR PARTICULATE SAMPLING OF HAZARDOUS AND MUNICIPAL WASTE INCINERATORS

Paul M. Lemieux, Joseph A. McSorley, and William P. Linak
U.S. EPA, AEERL
Research Triangle Park, NC

EPA's Air and Energy Engineering Research Lab (AEERL) has developed a prototype baghouse/dilution tunnel sampling system. This system was designed for the sampling of bulk particulate from Hazardous Waste and Municipal Waste Incinerators, for use in health effects related studies. The sampling system simulates the flue gas quenching processes occurring upon emission to the atmosphere. A 10:1 dilution with ambient air promotes nucleation of vapor phase organic compounds and their condensation on existing particulate. This unit is able to sample 2 dscm/min of effluent. At the allowable particulate loading rate of 180 mg/dscm, this sampler is able to capture approximately 20 g of sample in the period of an hour. At this rate, it is feasible to quickly generate kilogram-sized particulate samples for health effects research; large enough so that elaborate bioassay directed fractionation or skin painting tests can be performed. Subsequent samples can also be readily obtained, so that duplicate health effects tests can be performed, a luxury not normally available. It is also possible to perform gaseous sampling either upstream or downstream of the baghouse to determine gas phase organics that did not condense on the particulate.

EVALUATION OF ALTERNATIVE TREATMENT TECHNOLOGIES FOR HAZARDOUS WASTES FROM ACRYLONITRILE PRODUCTION

E. Radha Krishnan
PEI Associates, Inc.
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Ronald J. Turner
U.S. EPA, RREL
Cincinnati, OH

Three aqueous waste streams from acrylonitrile production have been included in the list of hazardous wastes under the U.S. Environmental Protection Agency's land disposal restrictions program: 1) the bottom stream from the wastewater stripper (EPA Hazardous Waste No. K011); 2) the bottom stream from the acetonitrile column (EPA Hazardous Waste No. K013); and 3) bottoms from the acetonitrile purification column (EPA Hazardous Waste No. K014). The listing constituents for K011, K013, and K014 include acrylonitrile, acetonitrile, acrylamide, and hydrocyanic acid.

Current practice in industry is to dispose of these wastes by deep well injection. These waste streams also contain suspended solids consisting primarily of spent metallic oxide catalyst particles and acrylonitrile polymers. Prior to deep well injection, the aqueous waste streams are comingled and treated in settling ponds/tanks where the suspended solids are separated as a sludge. Because the sludge is derived from hazardous wastes K011, K013, and K014, it has the same listing constituents as the aqueous waste streams.

This paper presents the results from: 1) a bench-scale evaluation of wet air oxidation as a treatment technology for the mixed K011/K013/K014 waste stream, and 2) a field investigation to evaluate the performance of rotary kiln incineration as a treatment technology for the sludge. The wet air oxidation tests were conducted at Zimpro Passavant's research facility in Rothschild, Wisconsin, and the incineration tests were conducted at the John Zink Company's test facility in Tulsa, Oklahoma.

THE ROLE OF SITE CHARACTERIZATION IN THE SELECTION OF CORRECTIVE ACTIONS FOR LEAKING UNDERGROUND STORAGE TANKS

David C. Noonan and Myron S. Rosenberg
Camp Dresser & McKee, Inc.
Boston, MA

Anthony N. Tafuri and Chi-Yuan Fan
U.S. EPA, RREL
Edison, NJ

There are numerous sites across the nation where soil treatment technologies are being applied to clean up soils contaminated with petroleum products from leaking underground storage tanks. Developing an accurate characterization of subsurface conditions at a site increases the likelihood that a selected soil treatment technology will be effective at a given site. This paper presents an approach for conducting a site characterization, including identifying what information about the subsurface environment and the released petroleum product is needed, and where it can be obtained. Default values are provided for most variables if field data are not yet available.

Worksheets are provided to help the reader make a preliminary determination as to where in the unsaturated zone most of the pollutants are likely to be, and where they are likely to move. Critical success factors, or factors for determining how effective a given soil treatment technology will be in cleaning up a particular site, are provided. The critical success factors for five soil treatment technologies are contained in the worksheets so that conditions at any site can be evaluated.

EVALUATION OF THE ACCURACY OF VOLUMETRIC LEAK DETECTION METHODS FOR UNDERGROUND STORAGE TANKS CONTAINING GASOLINE

Joseph W. Maresca, Jr., James W. Starr, and Robert D. Roach
Vista Research, Inc.
Mountain View, CA

John S. Farlow and Robert W. Hillger
U.S. EPA, RREL
Edison, NJ

A U.S. Environmental Protection Agency (EPA) research program evaluated the current performance of commercially available volumetric test methods

for the detection of small leaks in underground gasoline storage tanks. The evaluations were performed at the EPA Risk Reduction Engineering Laboratory's Underground Storage Tank Test Apparatus in Edison, New Jersey.

The evaluation approach used: (1) experimentally validated models of the important sources of ambient noise that affect volume changes in nonleaking and leaking tanks; (2) a large data base of product–temperature changes that result from the delivery of product to a tank at a different temperature than the product in the tank; and (3) a mathematical model of each test method to estimate the performance of that method. The test–method model includes instrumentation noise, configuration of the sensors, test protocol, data analysis algorithms, and detection criterion.

Twenty–five commercially available volumetric leak detection methods were evaluated. The leak rate measurable by them ranged from 0.26 to 6.97 L/h (0.07 to 1.87 gal/h), with a probability of detection of 0.95 and a probability of false alarm of 0.05. Three methods (as tested) achieved a performance of 0.38 (0.10 gal/h) or less, the 1988 standard promulgated by EPA.

The performance of the methods evaluated was limited primarily by test protocol, operational sensor configuration, data analysis, and calibration, rather than by hardware. The experimental analysis and model calculations suggested that substantial performance improvements can be realized by making procedural changes.

AN OUTREACH PROCESS: CASE HISTORIES OF UNDERGROUND STORAGE TANK CORRECTIVE ACTIONS

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CDM Federal Programs Corporation
Fairfax, VA

Robert W. Hillger and Richard A. Griffiths
U.S. EPA, RREL
Edison, NJ

The U.S. Environmental Protection Agency's (U.S. EPA's) regulations for underground storage tanks (USTs) require corrective action to be taken in response to leaking USTs. However, the experience of personnel in the U.S. EPA regions, the states, and the local environmental agencies varies widely. The U.S. EPA is expanding its Case History File data base to facilitate technology transfer among the personnel involved in UST corrective action and those involved in hazardous waste site cleanup. This information will allow UST personnel to obtain the immediate benefit of the experience of other people involved in UST and other cleanup activities.

The original Case History File contains reports filed by On-Scene Coordinators (OSCs) and Remedial Project Managers (RPMs) about the technical, administrative, financial, and other aspects of spill and/or waste site cleanups that they have handled. The file consists of a data base section and a narrative section. The data base section allows menu-controlled computerized searches to be made in any of 27 categories. The narrative section contains detailed reports on the response actions taken at the site. The narrative section is organized into 10 subsections: General Information, Chemical Information, Effects of the Incident, Site Characteristics, Containment Actions, Removal/Cleanup Actions, Treatment Actions, Disposal Actions, and Operational Considerations.

The original file has been modified to incorporate additional data relevant to USTs, such as methods of detection, causes of UST leaks, and tank/piping construction, etc. New reports are being added as the U.S. EPA Edison office receives them from the states and U.S. EPA regions.

This paper provides an overview of the UST Case History File, describes how the data was collected, analyzes the initial data including discussion of various technologies used for UST site cleanups, and provides a sample scenario of a data base search for a UST-related incident.

CONSIDERATIONS OF UNDERGROUND STORAGE TANK RESIDUALS AT CLOSURE

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Anthony Tafuri
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Edison, NJ

The EPA is currently evaluating several technical and regulatory aspects of underground storage tank (UST) closures. A key concern is the manner and extent of tank cleaning that is appropriate and feasible when a tank is removed from service. The objective of this work was to obtain a thorough technical/scientific understanding of UST residuals at closure: their origins, physical/chemical properties, ease of removal by different cleaning methods, and their environmental mobility and persistence. The information generated will be used as an aid in the regulatory process and will be useful to those implementing/overseeing closure activities.

Information was obtained via phone contacts with knowledgeable individuals, published and unpublished literature, site visits, and worksheets

completed by state representatives. The investigation was limited to underground storage tanks containing gasoline and diesel.

LABORATORY STUDIES OF VACUUM–ASSISTED STEAM STRIPPING OF ORGANIC CONTAMINANTS FROM SOIL

Arthur E. Lord, Jr., Robert M. Koerner, and Donald E. Hullings
Drexel University
Philadelphia, PA

John E. Brugger
U.S. EPA, RREL
Edison, NJ

A long–term research and demonstration project is underway to investigate vacuum–assisted steam stripping of organic chemicals from contaminated soil, and to develop a field unit to steam strip and collect such pollutants. In previous work, an analytical model was developed to model steam stripping in the field. The model involved steam flow to the surface from pipes embedded below the ground surface. The data needed to use the model were obtained from an effort that involved vacuum–assisted steam stripping of kerosene from a variety of soil types (from sands to silts) in small–scale laboratory experiments. This approach was used to determine the time to decontaminate a given kerosene spill in a particular soil. Small–scale pilot studies were also made of the field unit employing a unique geosynthetic, vacuum cap assembly. The results of this first phase of the work were quite promising.

The chemical analysis method in the first phase of the work used simple volume analyses of the collected kerosene and water fractions. More sophisticated analytical techniques are being used in the subsequent work to be reported here. Gas chromatography is employed to analyze for residual chemicals in the soil after steam stripping. Results will be reported for the efficiency in vacuum–assisted steam stripping of a series of alkane organic chemicals, ranging from hexane to dodecane, in all the soil types. In this way, the effect of chemical vapor pressure on the removal efficiency can be determined. The alkanes are non–polar; therefore, it is also of interest to investigate polar organics. Octanol and higher vapor pressure polar organics will be used.

As a result of this work, the utility of vacuum–assisted, steam stripping methods to decontaminate polluted soils will be on a much firmer technical basis.

LOW TEMPERATURE THERMAL DESORPTION FOR TREATMENT OF CONTAMINATED SOILS

Richard Lauch
U.S. EPA, RREL
Cincinnati, OH

Barbara B. Locke
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Performance of the low temperature thermal desorption process for removing contaminants from soils was evaluated. The data were necessary to assist EPA in the selection of Best Demonstrated Available Technology (BDAT) for treating Superfund soils. Soils from three Superfund sites were selected for treatment. The effect of temperature and residence time was determined when using both a tray and tube-type furnace. Temperatures of 150°, 350°, and 550°F along with residence times of 10, 20, and 30 minutes were tested. The differences in concentrations before and after treatment of volatile and semi-volatile organic compounds were used as a measure of treatment effectiveness. Metal concentrations before and after treatment were also determined. Results from these tests on actual Superfund soils were also compared to earlier results of tests on synthetic soils. The earlier tests showed that over 96 percent of volatile organic compounds and over 86 percent of semi-volatile organic compounds were removed at the 500°F temperature.

DETECTION OF MACRO DEFECTS IN SOIL-BENTONITE CUTOFF WALLS

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Soil-bentonite cutoff walls may be used to control the movement of contaminated groundwater as a temporary containment measure alone, or as an adjunct to a permanent remedial action. In either case, as-built or chemically-induced hydraulic defects ("windows") in these barriers represent continued environmental risk and may also control the cost of groundwater "pump and treat" operations where used.

This study involves the detection of buried "windows" based on intermittent monitoring of groundwater levels adjacent to a cutoff wall. The piezometric drawdown profiles for various artificial "windows" of known geometry and location were measured using conventional standpipes. The same conditions were examined using the MODFLOW groundwater transport

model (USGS, 1988) in order to validate MODFLOW as a numerical model for use in the study of field-scale "window" detection scenarios.

Preliminary results comprise data describing the maximum field spacing of standpipes, "L," that can be used to detect in-situ point-source leaks or "windows" of specified discharge rate at any depth below the groundwater table as a function of: a) piezometric head conditions at the cutoff wall and, b) the ratio of horizontal to vertical permeability of the host in-situ soils.

INNOVATIVE DELIVERY AND RECOVERY SYSTEMS: HYDRAULIC FRACTURING

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Hydraulic fracturing, a method of increasing fluid flow within the subsurface, should improve the effectiveness of several remedial techniques, including pump and treat, vapor extraction, bio-reclamation, or soil flushing. The basic method is straightforward: fluid is injected into a borehole until pressures exceed a critical value, fracturing the enveloping material. Sand pumped into the fracture holds it open and provides a high-permeability channelway suitable for either delivery or recovery.

Our investigations into using hydraulic fractures to facilitate remediation consist of theoretical analyses and bench-scale experiments of the hydraulic fracturing process in soil. Recently, we have conducted a field test using shallow boreholes in an uncontaminated site.

Preliminary results of the bench-scale experiments, the theoretical investigations, and the field test are all encouraging. In the experiments, blocks of clay-rich colluvium were loaded in a triaxial cell and hydraulic fractures were created by injecting dyed fluid through a tube resembling a borehole. Hydraulic fractures were successfully created in all tests conducted thus far. Remarkably, even extremely soft samples of saturated, loosely consolidated clay were readily fractured in the bench-scale apparatus.

Particularly promising results have come from the field experiment, where 10 hydraulic fractures were created at depths of 2 m in a tight, silty-clay till. In general, the fractures were slightly elongated in plan and they dipped gently (14° to 25°) toward the borehole. The largest fracture covered 90 m^2 in plan and extended 13.5 m from the borehole. More typically, however, the fractures covered roughly 20 m^2 in plan and extended 5 to 8 m from the borehole. Sand filling the fractures was up to 1 cm thick.

COMPUTER-BASED METHODS OF ASSESSING CONTAMINATED SITES: CASE HISTORIES

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A microcomputer-based system has been developed to evaluate data from hazardous waste sites. The system is capable of generating maps or cross-sections showing the geology, hydrology, or distribution of contaminants; of calculating volumes or masses of contaminated material; and of analyzing the transport of pollutants in the subsurface.

Most of the software packages used in the system are commercially available. They include a data base management system, a geographic information system, groundwater models, plotting packages, and a computer-aided design and drafting system. A few packages, such as the one used to calculate volumes and masses, were written for the project.

The transfer of data from one software package to another is a key element in the development of our system. It was accomplished by writing utility programs tailored to the I/O requirements of each software package.

The system has been tested using data from sites involving groundwater contamination from leaky landfills, air contamination from a train derailment, and soil-gas contamination from an unknown source. Benefits provided by the system include rapid evaluation of the distribution of contamination (and high-quality graphical representation), and characterization of hydrology and geology in three dimensions. Currently, we are using models of contaminant transport to evaluate possible remedial actions, such as excavation, pump and treat, cutoff walls, or interceptor ditches, at the sites characterized within the computer.

Application of the system is currently available as a technical assistance service to EPA regional offices. Results can be used to support decision making from initial data collection, to remediation and post-cleanup monitoring of contaminated sites.

ECONOMICS OF THE KPEG PROCESS FOR DECONTAMINATION OF PCBs IN SOIL

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The Naval Civil Engineering Laboratory and the U.S. EPA Risk Reduction Engineering Laboratory have completed a joint study of the KPEG Process to decontaminate PCBs in soil at the Naval Public Works Center in Guam. A two-ton pilot-scale batch reactor system was fabricated for the study. The reactor system consisted of a mixed reactor, a steam generator, and a steam condenser with a carbon absorber. Twenty tons of PCB contaminated soil, containing 1,000 to 2,000 ppm Arochlor 1260, were treated in thirteen batches. Spent carbon from the absorber, along with shredded protective clothing, were decontaminated by treatment with the KPEG Process. The treated soil and process effluents met treatment permit requirements.

Cost analysis of the treatment indicates that the KPEG Process economically decontaminates PCBs. The KPEG Process is estimated to cost no more than $200 per ton of soil. A full-scale (20-ton capacity) treatment system is in design. The full-scale system will be tested in late 1989 on a PCB contaminated site.

DESTRUCTION OF CYANIDES IN ELECTROPLATING WASTEWATERS USING WET AIR OXIDATION

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All of the technologies normally applied for the destruction of cyanide in waste streams containing cyanides and metals result in the generation of sludges which contain high concentrations of cyanide (500 to 1,000 mg/Kg). If the sludge, following dewatering, is destined for land disposal, there is a strong probability that it will have to undergo further treatment for the destruction of cyanide prior to its disposal to the land. One other possibility would be to treat the original waste stream by a technology which would destroy the cyanide prior to precipitation of the metals.

This paper presents the results of the application of Wet Air Oxidation for cyanide destruction to the original waste stream prior to sludge generation. This technology can also be applied to sludges generated by other technologies which contain high concentrations of cyanides.

COST-EFFECTIVE APPROACHES TO THE ENVIRONMENTAL CONTROL OF ELECTROPLATING OPERATIONS

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The U.S. EPA has sponsored a number of studies over the past few years to determine improved approaches available to achieve more cost-effective control of electroplating operations. These studies indicate that a multimedia process systems approach is likely to be the most effective in attaining the environmental pollution goals required by regulatory agencies while minimizing costs to do so.

The approach involved requires a number of steps. These include: (1) the careful analysis of the plating processes utilized and definition of the characteristics and the pathways of pollutant generation; (2) the analysis of the contribution of pollution prevention techniques to minimize the quantity of wastes formed; (3) selection of a combination of pollutant controls and ultimate disposal technologies which are allowable under the CWA, CAA, and RCRA; and finally (4) the development of a route to achieving the required environmental protection goals at least cost. This approach is based upon an iterative process which takes into consideration the capital and operating costs of a number of alternative pathways consisting of various combinations of pollution prevention, control, and ultimate disposal alternatives. The target sought is the scenario in which the multimedia environmental goals are obtained for all aspects of the operation at the minimum annualized cost for capital and operating expenses. An acceptable target, from the perspective of cost, is that scenario in which the annualized cost for installation of pollution prevention and control technologies, including the costs of residual management, is offset by the savings achieved in waste disposal costs for the existing waste management case.

SESSION B
ABSTRACTS

PCB DEGRADATION: STATUS AND DIRECTION

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There is varied experimental activity to develop effective means of destroying PCBs polluting the environment as hazardous wastes in soils, sediments, water, and even in storage. One promising area of research has resulted from recognition of the potential for achieving environmentally harmless cleanup of PCBs by the use of biological processes. This paper reviews the status of PCBs as pollutants, the current knowledge of microbial degradation of PCB compounds, and the attempts to develop technology for their control. Current information on degradation by mixed cultures, pure cultures, aerobic and anaerobic processes, and the degradative relationships between various microorganisms and substrate structure are discussed. Emphasis is on the importance of knowledge of breakdown pathways resulting from metabolic action of microorganisms on PCBs. This information is vital to the successful development, through genetic engineering techniques, of strains with improved capability for degradation. Pertinent metabolic activity and related genetic processes are presented as a basis for the rationale for ongoing research utilizing applied genetics to develop microbial strains that will be super degraders of the PCBs in the environment.

THE DEVELOPMENT OF RECOMBINANT BACTERIA FOR POLYCHLORINATED BIPHENYL DEGRADATION

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Pseudomonas strain LB400 and Alcaligenes eutrophus strain H850 have previously been demonstrated to degrade an unusually wide variety of polychlorinated biphenyls (PCBs). The genes encoding the PCB degradative enzymes (the bph genes) from these organisms were isolated using the broad-host-range cosmid vector pMMB34, and found to be expressed in Escherichia coli. A comparison of the PCB degradative capabilities of the wild-type and recombinant strains was conducted using resting-cell assays. Significant improvements in the activity of the recombinant strains were observed after plasmid modifications. The degradation of a variety of PCB mixtures including Aroclor 1242 was found to be comparable for LB400 and the recombinant strain FM4560. Unlike LB400, FM4560 did not require growth on biphenyl to achieve high levels of degradative activity. This may be an important advantage in future biotreatment applications.

Southern hybridization analysis was used to determine that the genes encoding PCB degradation in LB400 and H850 are genetically distinct from those in a variety of organisms. This indicates the existence of at least two different classes of genes for PCB metabolism. The availability of DNA probes for the LB400/H850 class of bph genes will make it possible to determine the fate of recombinant strains or plasmids containing these genes in bioremediation processes.

TREATMENT OF WOOD PRESERVING SOIL CONTAMINANTS BY WHITE ROT FUNGUS

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A wood degrading fungus, Phanerochaete chrysosporium, has been the object of considerable attention for its potential application to hazardous waste degradation. The development of a field-worthy soil treatment technology based on this fungus has been the focus of an intense research program. Early stages of this work sought to determine ways to assist the growth of the fungus in soil, an environment not known to be sought by this fungus. Once general methodology was established to promote its sustained growth, studies were pursued to quantitatively determine the extent of biodegradation attributable to the fungus using surrogate soils (artificially contaminated with wood preserving waste constituents). Work with pentachlorophenol and related polyaromatic hydrocarbons has paved the way to undertake limited field trials during the North American growing season of 1989. The related bench-scale experimental work and some information concerning the field trials will be presented.

BIOLOGICAL TREATMENT OF PETROCHEMICAL SLUDGES

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The research results of using a microbial population acclimated to petrochemical waste sludges to degrade the complex hazardous organic substrates found in these sludges are presented. The results obtained include the determination of microbial population stability, rates of growth, and substrate utilization for selected single compound substrates and two API separator sludges. Specific growth rates as high as 0.38 hr-1 have been obtained for an API separator sludge treated in a batch reactor loaded with five percent oil (v/v). Cultural stability appears to have been established after three months of continuous loading in complete-mixed

stirred tank reactors for two different API separator sludges; microbial composition differs for each of the API sludges. These results are being included in a growth rate model to relate specific growth rate to substrate concentration and desorption rates of organic compounds from the inorganic solid constituents as a function of microbial culture activity. The results of this research are the initial step towards a detailed description and evaluation of biological treatment of complex organic hazardous waste sludges.

THE DETERMINATION OF BIODEGRADABILITY AND BIODEGRADATION KINETICS OF ORGANIC POLLUTANT COMPOUNDS WITH THE USE OF ELECTROLYTIC RESPIROMETRY

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Electrolytic respirometry is being applied to the fate studies of priority pollutants and Resource Conservation and Recovery Act (RCRA) toxic organics to generate data on their biodegradability and on biodegradation/inhibition kinetics, and involves natural sewage, sludge and soil microbiota. The report discusses the experimental design and procedural steps for the respirometry biodegradation and toxicity testing approach for individual organics or specific industrial wastes. The discussion also includes a review of the electrolysis biochemical oxygen demand (BOD) measuring system inherent in electrolytic respirometry, and the factors affecting respirometric determination and measurement of respiration rate.

The report outlines a developed multi-level protocol for determination of the biodegradability, microbial acclimation to toxic substrates, first order kinetic parameters of biodegradation (μ and μ'), and estimation of the Monod kinetic parameter (μ_m, K_s, and Y_g) of toxic organic compounds. This protocol is provided in order to correlate the extent and rate of biodegradation of these organics with a predictive model based on chemical properties and structure of these compounds.

Respirometric biodegradability and biodegradation kinetic constant data from OECD studies undertaken to develop a confirmatory respiration biodegradability ring test are provided for selected non-inhibitory and non-adsorbing compounds, tetrahydrofuran, hexamine, pentaerythritol,

1-naphthol, sodium benzene sulphinate, thioglycolic acid, and the biodegradable reference compound, aniline. The report includes respirometric biodegradability and biodegradation/inhibition rate data for representative RCRA alkyl, chloro- and nitrobenzenes, phenolic compounds, phthalate esters, ketones, and nitrosamines, as well as selected Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) leachate toxic organics.

PREDICTION AND MODELING OF BIODEGRADATION KINETICS OF HAZARDOUS WASTE CONSTITUENTS

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Biodegradation is the most important mechanism in controlling the concentration of chemicals in the aquatic system because it can mineralize toxic pollutants to innocuous forms. So, the fate of organic chemicals, in an aquatic environment, is dependent on their susceptibility to biodegradation. Because of the large number of chemicals, it will be expensive and labor intensive to gather this information in a reasonable amount of time. Hence, there is a need for a prediction method to obtain these data.

Experiments, using a electrolytic respirometer, were conducted to collect oxygen consumption data for some Resource Conservation and Recovery Act (RCRA) compounds, and first order kinetic rate constants were obtained. Using these data, along with those from literature, a structure-activity relationship will be developed.

MICROBIAL TREATMENT OF CONTAMINATED SOIL FINES

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Remediation of CERCLA impoundments and lagoons often results in the removal and treatment of contaminated wastes, leaving underlying and adjacent soils for decontamination and cleanup. Contaminated soils that surround a lagoon containing still bottoms from aromatic solvent production

are the focus of this study. High concentrations of polynuclear aromatic species (PNAs) and chlorinated solvents are the principal problem. Heavily contaminated soil fines have been separated from bulk soil. Separation was achieved through use of sodium salt solutions as clay dispersants, and resulted in a relatively clean, sandy residual and the contaminated fine material. Anaerobic and aerobic degradation of contaminants on slurried fines has been underway for some time.

FATE OF RCRA AND CERCLA TOXICS IN ANAEROBIC DIGESTION OF PRIMARY AND SECONDARY SLUDGES

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Municipal wastewaters have been shown to contain toxic organics, many of which are anthropogenic. Sorption onto solids is one of the primary means of removal of these chemicals. This study investigates the steady-state fate and effects of organic priority pollutants sorbed on primary and secondary sludges during subsequent treatment in anaerobic digesters. The investigation consisted of two separate studies of pollutants: volatile organics chosen from the Resource Conservation and Recovery Act (RCRA) list, and semi-volatile organics from the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) list. Simulating typical digestion processes, three bench-scale CSTR units with a total volume of 40 liters each were operated with a solids retention time of 30 days at 35°C. Primary and secondary sludges were combined in equal weight ratios prior to feeding to the digesters. Conventional operating parameters were monitored for the one control and two organic-spiked digesters to assess differences in performance.

The fates of six of the volatile compounds which showed consistent behavior, including several chlorinated aliphatics and ethylbenzene, were determined by purge and trap gas chromatographic analyses. Steady-state fates of 11 of the semi-volatile organics, which included dichlorobenzenes, phthalates, p-cresol, and lindane, were determined by gas chromatographic/mass spectroscopic analyses.

FATE AND EFFECTS OF SELECTED RCRA AND CERCLA COMPOUNDS IN ACTIVATED SLUDGE SYSTEMS

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Two separate studies were conducted to investigate the removal and fate of 28 selected Resource Conservation and Recovery Act (RCRA) compounds (0.25 mg/l of each compound) and 19 selected Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) compounds (0.5 mg/l of each compound) in conventional activated sludge treatment. Two pilot-scale (35 gpm) activated sludge systems (SRT: four days for the RCRA study and eight days for the CERCLA study) were operated in parallel over a period of 10 months at the U.S. EPA Test & Evaluation Facility in Cincinnati, Ohio. Both acclimated and unacclimated conditions were studied. The selected RCRA or CERCLA compounds did not cause any adverse effects on the chemical oxygen demand (COD) and suspended solids (SS) removal. The concentrations or masses of the organics in the various samples from the treatment systems revealed good results in the air samples from the RCRA study and reasonable results in the secondary effluents for both studies. The concentrations of organics (RCRA study) in the air emissions indicated that the chlorinated aliphatic solvents were essentially volatilized into the plant air emission stream, whereas the aromatic volatile benzenes (e.g., toluene, xylenes, and chlorobenzenes) were substantially degraded. Nondegradable pesticides were removed by sorption on sludges. Unfortunately, the variability in the results did not reliably permit calibration of the mechanistic model developed from treatability studies. Additional work is planned to attempt to reduce the analytical variability encountered in these studies.

COMPATIBILITY OF FLEXIBLE MEMBRANE LINERS AND MUNICIPAL SOLID WASTE LEACHATES

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This paper describes the results of a survey of the open technical literature relating to the composition of currently produced municipal solid waste

(MSW) leachate, the compatibility of flexible membrane liners (FMLs) with such leachate, and the results of limited experimental work designated to obtain needed information with respect to some areas of concern.

The results of the survey revealed little information on the compatibility between the FMLs currently being used in constructing disposal facilities and MSW leachates. Some information was available from studies from the 1970s. In addition, little information was available on the composition of MSW leachates currently being produced except that concentrations appear to be low and that current leachates may potentially contain more of the polluting organics which are less degradable and may be more aggressive to FMLs.

Because of uncertainties about the compatibility of FMLs and MSW leachates and the absorption of organics from dilute solutions, such as leachates, limited laboratory testing was performed to determine the partitioning of selected organics from dilute aqueous solutions to various types of FMLs. The results show that, depending on the relative solubility parameters of the organics and the FMLs, some of the organics tend to partition from the water into the FMLs. The organics partitioned between water and the different FMLs at different ratios, and the FMLs varied considerably in their absorption of the different organics.

GEOSYNTHETIC CONCERNS IN LANDFILL LINERS AND COLLECTION SYSTEMS

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The use of geosynthetic materials, such as flexible membrane liners (FMLs), geonets, and geotextiles, in landfills, surface impoundments, and waste piles is common in many containment facilities. While such systems are performing well and the data base regarding their use is developing, there exist several areas of concern where further investigation is warranted. This project focuses on these topics, each of which will be presented in this paper.

(a) Biological Clogging of Leachate Collection Sytems

Leachates from six municipal landfill sites are being used to evaluate biological clogging of geotextile filters. Both aerobic and anaerobic tests have been conducted for 12 months. To widely varying degrees, biological clogging is occurring. It appears that the BOD5 of the leachate is the best indicator of this activity. Biocide remediation schemes are currently ongoing.

(b) Sediment Clogging of Leachate Collection Systems

The focus of this laboratory study is on fine sediment clogging of geotextile filters. The sediment might come from an overlying soil cover or be the actual solid matter within the landfill leachate. Current geotextile opening size design has not addressed this type of very small particle size from either leachate permeability or sediment retention perspectives.

(c) FML Anchor Trench Behavior

The terminus of an FML in an exterior anchor trench or an interior berm is an important design element of a waste containment system. A full-scale laboratory simulation strain gaging 3.0 feet (0.91 m) wide sheets of different FMLs is being conducted to note their behavior under varying amounts of normal stress. Results are being compared to existing design models.

(d) Stress Cracking of HDPE Seams

Concern via a series of laboratory tests has been focused on stress cracking of HDPE liner seams. Current efforts are toward an assessment of the quality control in making the seams and determining if the situation exists in field installations. A number of related features are also being investigated, e.g., crack initiation, crack growth rate, residual stress determination, and seam geometry optimization.

ATTENUATION OF PRIORITY POLLUTANTS CODISPOSED WITH MSW IN SIMULATED LANDFILLS

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Organic and inorganic priority pollutants codisposed with shredded municipal solid waste (MSW) in 10 pilot-scale simulated landfill columns, operated under single pass leaching or leachate recycle, were capable of being attenuated by microbially mediated landfill stabilization processes. Detailed investigations have indicated that inorganic heavy metals (Cd, Cr, Hg, Ni, Pb, and Zn) were subject to a complex array of attenuation mechanisms within the MSW matrix, including precipitation, encapsulation, complexation, reduction, adsorption, and ion exchange. Similarly, the major classes of organic priority pollutants (aromatic hydrocarbons, halogenated hydrocarbons, pesticides, phenols, and phthalate esters) were

attenuated mainly by volatilization, sorption, and bioassimilation with the release of identifiable byproducts within the leachate and gas transport phases.

Collectively, these in-situ processes constitute the assimilative capacity of the landfill setting for priority pollutants, the magnitude of which is dependent on microbial viability during the sequential phases of landfill stabilization as affected by loading intensity and contact opportunity. Data are presented to demonstrate the principal assimilative mechanisms as well as the efficacy of in-situ process control through leachate and gas management. Based upon these findings, a landfill management strategy is proposed for landfills receiving inputs of organic and inorganic priority pollutants.

SITE DEMONSTRATION OF THE HAZCON PROCESS

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In October 1987, the HAZCON stabilization process was tested and evaluated at the Douglassville, Pennsylvania, Superfund site. There was extensive physical and chemical testing of the untreated and treated waste samples. Stabilized wastes were also stored underground on site as a field durability test. After 270 days (July 1988), these wastes were dug up and the samples obtained were tested for any changes in chemical and physical properties. The wastes were reburied and will be sampled again in July 1989.

The durability of the treated samples was determined by comparing the 28-day and the 270-day test results. Test results of the HAZCON 270-day samples indicated a slight loss in long-term durability, but because of the data scatter this may not be statistically important. There was some loss in Unconfined Compressive Strength (UCS) in the low oil and grease samples (< 5%), but in the high oil and grease samples (16 to 25%), the UCS strength increased. TCLP leachate concentrations for lead remained low (ppb), and the VOC, Base/Neutral/Analysis (BNA), and PCB leachate concentrations appeared lower than the 28-day sample results. A noticeable decrease in the porosity of the samples was observed. Overall, there was not a major change in sample characteristics and some durability was demonstrated.

RESULTS OF THE SITE PROGRAM DEMONSTRATION OF THE TERRA VAC IN-SITU VACUUM EXTRACTION TECHNOLOGY

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An evaluation was made of the performance of Terra Vac Inc.'s vacuum extraction system during a 56-day SITE program demonstration test run at Valley Manufactured Product Company's site in Groveland, Massachusetts. This site is part of the Groveland Wells Superfund site, a source of drinking water for the town of Groveland, and is contaminated mainly by trichloroethylene.

This paper includes a detailed discussion of the operations of the vacuum extraction unit, a process description and diagram of the system, and a summary of the sampling and analytical protocols. An overall cost evaluation of the process is included, and conclusions are drawn regarding the efficiency of the process and its applications to other Superfund sites across the country.

Results of the demonstration test are promising, and it is felt that a site remediation can be accomplished using this technology. Both shallow soil gas and soil VOC concentrations were reduced substantially, and wellhead VOC gas concentrations showed a decline with time which could be correlated. The process worked well in soils of both high and low permeability.

The system operation was very reliable during the 56-day demonstration test run and the only operation attention required was to replace the spent activated carbon canisters with fresh canisters.

OVERVIEW OF THE WASTE REDUCTION INNOVATIVE TECHNOLOGY EVALUATION (WRITE) PROGRAM

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A new national research program is being undertaken by the U.S. EPA: the Waste Reduction Innovative Technology Evaluation (WRITE) Program. The WRITE Program is designed to identify, evaluate, and/or demonstrate the use of innovative engineering and scientific technologies to reduce the volume and/or toxicity of wastes produced from the manufacture, processing, and use of materials. The WRITE Program is broad in technical scope and addresses the reduction of pollutants across all environmental media: air, land, surface water, and groundwater. This research program is directed by the Waste Minimization Branch of the Risk Reduction Engineering Laboratory in the Office of Research & Development.

Several activities are being conducted under the WRITE Program. The "WRITE Pilot Program with State and Local Governments" addresses immediate information transfer needs between government and industry. Technical and economic evaluations of source reduction and recycling technologies of manufacturing and processing operations across approximately 20 industries are being conducted through the joint efforts of EPA and various state and local governments. The "WRITE Program With Industry" focuses on evaluations of waste reduction technologies currently in use or under development by large industries. One of the objectives of this program is to encourage the transfer of knowledge and technology concerning pollution prevention practices between large, mid-size, and small industries. The "WRITE Research Program" focuses on pollution prevention research needs, i.e., the generation of data to allow the future demonstration of emerging new pollution prevention techniques. Projects under this component of the WRITE Program address various technical obstacles to waste reduction and to chemical-, waste stream-, and industry-specific waste minimization issues. This paper provides an overview of the WRITE Program and discusses ongoing projects within each area of the program.

SOLIDIFICATION/STABILIZATION AS A BEST DEMONSTRATED AVAILABLE TECHNOLOGY FOR RESOURCE CONSERVATION AND RECOVERY ACT WASTES

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Early in 1987, the U.S. Army Engineer Waterways Experiment Station (WES) was requested under interagency agreement with the U.S. Environmental Protection Agency (U.S. EPA) to evaluate solidification/stabilization (S/S) as a Best Demonstrated Available Technology (BDAT). Under this program, EPA supplied WES with a number of Resource Conservation and Recovery Act (RCRA) listed hazardous wastes for evaluation.

In this evaluation, a total of nine listed wastes were solidified/stabilized using three generic S/S processes. Portland cement, kiln dust, and lime/flyash were the binders utilized in these S/S processes. The physical and leaching characteristics of the S/S materials were evaluated. Physical characteristics were evaluated using the unconfined compressive-strength (UCS) test. The waste-leaching characteristics were evaluated using the toxicity of characteristic leaching procedure (TCLP). The TCLP extracts were analyzed for a total of 22 metals. No attempts were made to analyze for semi-volatile and volatile compounds in the TCLP extracts, due to the absence of the compounds in the raw wastes. By comparing the TCLP extract results of the raw (unsolidified/unstabilized) waste to the TCLP extract results of the solidified/stabilized waste, the effectiveness of the S/S processes in immobilizing the metals was evaluated.

Preliminary results of the physical tests indicate that the solidified/stabilized wastes developed strength ranging from not measurable to 4,400 psi. The results of the TCLP indicate that Mercury and Arsenic concentrations as high as 85 and 118 mg/l, respectively, were leached from the solidified/stabilized wastes. The effectiveness of the S/S processes appears to be dependent on the specific waste and metal of interest.

VOLATILE EMISSIONS FROM STABILIZED WASTE

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This paper describes a system that was built and successfully tested for measuring the air emissions of Volatile Organic Compounds (VOCs) from the solidification of hazardous wastes and from the solidified wastes themselves. It also presents the results of parametric studies which measured the VOC emissions from two types of synthetic hazardous wastes solidified with two different types of agents under several different conditions.

The synthetic hazardous wastes tested were: 1) an inorganic "waste" made of soil and water, and 2) an organic "waste" made of soil, water, and latex paint sludge. The "wastes" were doped with either acetone and trichloroethylene (TCE), representing volatile compounds, or n-pentanol (amyl alcohol), representing a semi-volatile compound. The binders used were: 1) a mixture of 50 percent flyash/50 percent lime kiln dust and 2) portland cement.

Emission measurements showed that as much as 90 percent of the VOCs that were added to the "waste" were released during the solidification process. Additionally, as much as 60 percent of the remaining VOCs were released from the solidified wastes within the first 30 days after solidification. The tests also showed that solidification did not reduce the VOC emissions significantly. In fact, during processing, the emissions from the "wastes" being stabilized were significantly higher than from the same material being treated in the same manner but without the addition of solidification agents.

TECHNOLOGIES APPLICABLE FOR THE REMEDIATION OF SUPERFUND RADIATION SITES

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This paper identifies technologies that may be useful in removing or stabilizing radiological contamination from uncontrolled hazardous waste (Superfund) sites containing radionuclides. The radioactive materials at some Superfund sites consist primarily of waste from radium, uranium, and thorium processing. Twenty-five existing Superfund sites are known to contain radionuclides.

Sites contaminated with radionuclides pose a unique problem because, unlike organic wastes, radionuclides cannot be destroyed by physical or chemical means; they can only decay at their natural rate. Thus, alteration or remediation of the radioactive decay process, thereby changing the fundamental hazard, is not possible. Several technologies have potential for eliminating or stabilizing radionuclides at Superfund sites. These fall into the categories of on-site and off-site disposal, on-site treatment, chemical extraction, and physical separation. Applicability of these technologies is controlled by site-specific factors, and their feasibility must be determined on a site by site basis.

SESSION A/B ABSTRACTS

RRELEVANT QA DIAGNOSTICS: MAJOR FINDINGS IN FY '88

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This paper evaluates the RREL QA Program by considering its impact on specific projects undertaken during FY '88. During FY '88, RREL reviewed 108 QA Project Plans (the major document describing QA requirements for data generation). Typical problems identified during these reviews included poorly defined objectives, incorrect sampling and analytical methods, incomplete or inappropriate methods for measuring precision or accuracy, and sampling strategies which did not match the project objectives. Before experimental efforts began, these concerns were resolved, thereby avoiding potentially serious experimental flaws. A total of 61 on-site technical audits have been carried out during sampling and analytical activities. At times, these Technical Systems Audits have resulted in major changes, such as discontinuation of work at a laboratory. More commonly, problems were corrected promptly by the analytical laboratory or field team before the integrity of the project was compromised. Audits of Data Quality (ADQs) were carried out less frequently during FY '88, but nevertheless resulted in substantial impacts. For example, an ADQ of one project revealed that much of the required QD data had not been collected, and consequently much of the analytical data were of limited usefulness. This finding was valuable for EPA policy makers as well as for the management of follow-on projects. The last component of the RREL extramural QA Program was review of final reports, which provided constructive feedback to RREL regarding the success (or failure) of the project. Typical problem areas identified at this stage were insufficient presentation of QA data or overly generalized conclusions.

EFFECT OF FEED CHARACTERISTICS ON THE PERFORMANCE OF EPA'S MOBILE INCINERATION SYSTEM

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Under the sponsorship of the Office of Research and Development of the U.S. Environmental Protection Agency (EPA), a mobile incineration system (MIS) was designed and constructed to demonstrate the high-temperature incineration of toxic and hazardous wastes. The system consists of a refractory-lined rotary kiln, a secondary combustion chamber (SCC), and an air pollution control system mounted on three heavy-duty semi-trailers. Monitoring equipment is carried by a fourth trailer.

The MIS was constructed and rigorously tested in Edison, New Jersey, during 1982 to 1983 with PCB-contaminated liquids and other chlorinated organic fluids. The system was transported to the Denney Farm site in McDowell, Missouri, in December 1984 for a dioxin trial burn and field demonstration. During 1985 and 1986, 900,000 kg of dioxin-contaminated solids and 82,000 kg of dioxin-contaminated liquids were incinerated. During 1987, the MIS was modified to approximately double its capacity and to improve its reliability. A second trial burn was conducted on both solids and liquids contaminated with chlorinated organic compounds and PCBs during August and September of 1987. Since 1987, an additional 3,200,000 kg of solids and 31,000 kg of liquids have been successfully decontaminated. The results of testing at Edison, the trial burns, and the field demonstrations have been reported previously.

This paper will identify the significant feed characteristics which affect incineration system performance, describe the manner in which the feed characteristics affected MIS performance, correlate various feed characteristics with the affected parts of the system, describe actions taken to mitigate problem characteristics, and discuss the ultimate limits imposed on capacity and reliability by the various feed characteristics.

Feed characteristics caused capacity to vary from 90 kg/hr to a maximum of 2,400 kg/hr. Factors which limited capacity were chlorine content, moisture content, heating value, density, slagging tendency, rheological behavior, and other physical properties. Each of these characteristics affected one or more parts of the system. For instance, instabilities in the quench system and mist carryover from the scrubber limit capacity to about 115 kg/hr of organic chloride content. Heating value and moisture content limit capacity to between 90 and 910 kg/hr due to kiln temperature limitations and/or secondary combustion chamber residence time limits.

LONG-TERM FIELD DEMONSTRATION OF THE LINDE OXYGEN COMBUSTION SYSTEM AT THE EPA MOBILE INCINERATOR

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This paper summarizes the various system performance tests and the long-term operating experiences of the LINDE Oxygen Combustion System (OCS) at the EPA Mobile Incinerator. The LINDE OCS was installed in the EPA Mobile Incinerator as part of a major modification program in 1987. The operation of the modified system began in June 1987 for a three-month demonstration period during which various system performance tests were conducted in addition to around-the-clock incineration operation. Thereafter, the system resumed operation in February 1988 to continue the incineration of dioxin-contaminated materials from sites in western Missouri. To date, over seven million pounds of dioxin-contaminated material including soil, lagoon sludge, plastics, trash, grass, protective clothing, wood, etc., have been processed.

The capacity of the Mobile Incinerator for contaminated soil was more than doubled due to the OCS and modifications to the feed system. Test burns of the unit at increased capacity show DREs surpassing RCRA and TSCA standards. Recently, the Mobile Incinerator has been used successfully to burn brominated sludge materials with high heating value. Continuous water spray was used to absorb excess heat release. The OCS and other modifications have been instrumental for maximizing throughput of the brominated sludge material.

The OCS also has excellent response, which has significantly reduced the frequency of waste feed shutdowns due to low oxygen and high carbon monoxide caused by fluctuations of the Btu content in the waste feed. It was also shown that nitrogen oxides emissions from the oxygen enriched operation compare favorably with the previous air-based operation due to the unique design of the LINDE burner. Some common considerations about oxygen combustion and experiences learned during this operation will also be discussed.

Operation of the system has shown that the OCS and other modifications have improved the economics and reliability of the system. Some economic analysis will be presented.

IN PLACE TREATMENT OF CONTAMINATED SOIL AT SUPERFUND SITES

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U.S. EPA and other groups are developing methods to be used at Superfund sites for in-place contaminant removal (with treatment at the surface) and for complete in-place (in-situ) treatment of contaminated soils. This work is driven by the costs for managing large volumes of soil with low levels of contamination, and by the need to comply with provisions of the Superfund Amendments and Reauthorization Act (SARA) and the Resource Conservation and Recovery Act (RCRA). This paper summarizes available information sources and improvements in technology since 1984 when EPA issued a summary report on in-place soil treatment.

Effective transport of materials into and out of the subsurface and the attainment of complete mixing continues to present a major barrier to in-place cleanup of contaminated soils. Many potential treatment processes have been identified; few have been implemented because of this difficulty. In-place solidification/stabilization for treatment of metals is a widely used process that is limited by the transport/mixing problem.

Consideration of thermodynamics suggested that effective treatments for organic contaminants could be based on aqueous solution chemistry or gas phase chemistry. When the kinetics of processes are also considered, removal/treatment via the gas phase becomes more attractive. Several removal processes (vacuum extraction, steam stripping) are using this route for volatile organic compounds and it appears that these processes can be applied to organics with higher boiling points. Two other removal processes, in-situ soils washing (aqueous phase) and microwave heating (gas phase) are also promising. Overall, in-situ removal processes have been more successful than in-situ treatment processes.

A CLAIMS AVOIDANCE EXPERT SYSTEM

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The reduction of construction claims and the expedition of change order proposals are measures of successful project management in the Environmental Protection Agency's (EPA) Superfund program. A complex structure of legal knowledge and reasoning procedures is used to evaluate change order proposals. Expert systems, computer software applications which simulate the thought processes and reasoning of experts in the field,

are ideal tools to provide uniform, unbiased evaluations of specific events occurring on Superfund sites. Unforeseen physical site conditions, or conditions which differ from the contract indications, are events which often require expert legal advice to resolve disputes and avoid claims. Based on legal, factual, and technical information, a knowledge-based expert system can aid the user in assessing the constructor's probability of entitlement for the additional cost or time requested due to alleged differing site conditions.

Under contract to EPA's Risk Reduction Engineering Laboratory (RREL) and the Office of Solid Waste and Emergency Response (OSWER), CDM Federal Programs Corporation is combining two differing site conditions expert system prototypes into a fully operational system, SuperDiSC, to be implemented in FY '89. Containing over 260 production rules, this system is being developed for use on an IBM (or compatible) microcomputer system using KnowledgePro, an expert system development tool.

Uses of SuperDiSC include applications for both field personnel and management. As a field support tool, SuperDiSC will provide the contracting party (resident engineer) with a uniform and reproducible methodology for analyzing the need for a change order. The system would prevent disputes or reduce their effects, and thus would minimize the number of claims brought by the constructor. It will help improve the uniformity of decisions and accelerate the resolution of change orders, thereby keeping constructors on schedule and within budget.

EPA must respond to requests for change orders as quickly as possible to avoid schedule delays. SuperDiSC will produce documentation to assist Remedial Project Managers, or other EPA personnel, in reviewing requests for change orders. Documentation created at the site would provide complete background information and point out dispute areas. Given the background information and a copy of the pertinent issues involved in settling the dispute, the change order resolution process would be accelerated and delays in construction avoided.

As a training tool, SuperDiSC would allow a user to analyze cases with differing facts, yielding a variety of results. As the input changes, the user can observe the impact on the results. The system will provide a complete analysis of potential change orders or claim situations. Finally, the system's complete documentation of the thought process involved will increase the knowledge of the novice user, and thus is a very valuable training aid.

ASSESSMENT OF CHEMICAL AND PHYSICAL METHODS FOR DECONTAMINATING BUILDINGS AND DEBRIS AT SUPERFUND SITES

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Many Superfund sites contain buildings, building materials, and debris that are contaminated with one or more toxic organic and/or inorganic chemicals. To date, no generally applicable decontamination technique has been developed for the removal of organic contaminants such as polychlorinated biphenyls (PCBs) from the various materials included in a modern-day structure. The objective of this study was to evaluate chemical and physical methods for decontaminating buildings and debris at Superfund sites.

For evaluation of techniques designed to remove PCBs from concrete floors in buildings, concentrations of PCBs in the top 1/2 inch of the contaminated concrete floor were determined before and after treatment by analyzing cores obtained from selected locations in the floor. An innovative process for decontaminating debris was also designed, assembled, and evaluated. After bench-scale experiments were performed to determine an optimal solution for cleaning PCB-contaminated, corroded, metallic components, a 300-gallon, pilot-scale module was designed and field-tested at a Superfund site.

The results obtained during this study were very promising, and the techniques evaluated showed a great deal of potential for removing PCBs from concrete flooring and from the surface of the contaminated debris. This paper discusses the procedures and the analytical results of both the chemical and physical decontamination techniques evaluated during this study.

SESSION C
ABSTRACTS

IMMOBILIZATION MECHANISMS IN SOLIDIFICATION/STABILIZATION USING CEMENT/SILICATE FIXING AGENTS

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Lime treatment of aqueous solutions of heavy metal ions prior to solidification/stabilization produces a sludge which is ordinarily assumed to consist of a mixture of the corresponding metal hydroxides. Cadmium and lead hydroxides have comparable, and very low, solubilities in water. Nevertheless, the behaviors of the corresponding sludges toward cement solidification are quite different. We have investigated this behavior for both sludges and soluble Cd and Pb salts using TCLP leaching tests, conduction calorimetry, and solid-state nuclear magnetic resonance spectroscopy as a function of time. Concentrations of Cd in leachates are very low, while Pb concentrations are considerably higher and would represent a serious threat to groundwater. We believe that the leachability differences arise for a number of reasons. The Cd/cement system involves early formation of Cd(OH) (either before cement is added in the case of a sludge or immediately afterward in the case of a soluble Cd salt), which then provides nucleation sites for precipitation of CSH and calcium hydroxide, resulting in Cd being in the form of the insoluble hydroxide with a very impervious coating. On the other hand, the Pb/cement system is much more complicated in terms of the precipitation reactions. In the presence of hydroxide, sulfate, and (in the case of the soluble Pb salt) nitrate, mixed salts are precipitated which contain all three anions. These salts retard cement hydration reactions by forming an impervious coating around cement clinker grains. However, as pH in the cement pore waters undergoes fluctuations during the progress of hydration, the Pb salts undergo solubilization and reprecipitation. The result is the presence of Pb salts on the surfaces of cement minerals even in mature cement pastes. These Pb salts are readily accessible to leach water, and are apparently more soluble under the basic conditions than a pure lead hydroxide would be.

WASTE REDUCTION EVALUATIONS AT FEDERAL SITES

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The Waste Reduction Evaluations at Federal Sites (WREAFS) Program focuses on waste minimization research opportunities and technical

information transfer within the federal community. Many federal activities are implementing waste reduction plans and programs to reduce the generation of wastes. For example, an overall goal within DOD is to reduce hazardous waste generation a total of 50 percent by 1992 in comparison with 1985 levels. There are several operation and process opportunities for pollution prevention practices at federal sites, which will reduce wastes and result in cost avoidance or cost reduction as well as increased productivity, environmental, and human health benefits. Waste minimization technologies can be applied throughout the federal community in fabrication, production, and/or maintenance processes depending on the waste generating function. Industrial activities which support the federal community through in-house or contract efforts whether on-site or off-site are generally the same activities practiced within the private sector. The application of waste minimization research may vary depending on the production or consumption function; however, waste reduction techniques and technologies will work in both the federal or private sectors. WREAFS Program objectives include: conducting waste minimization workshops; developing technical information transfer opportunities between industry and government; providing EPA research information to the federal community; performing waste minimization opportunity assessments at selected federal sites; demonstrating waste minimization techniques or technologies at federal facilities; and promoting waste minimization within all portions of the federal community.

DEMONSTRATED COMPUTER ASSISTED ENGINEERING (CAE) TECHNIQUES FOR REMEDIAL ACTION ASSESSMENT

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A computer workstation dedicated to remedial action assessment is being developed. The system is composed of several off-the-shelf software and hardware modules, with software development limited to the integration of these modules. The component modules include a Geographic Information System, a Data Base Management System, a Computer Aided Design and Drafting System, and a Groundwater Modeling System. The completed system will be an example of a Computer Assisted Engineering (CAE) system.

The purpose of the project is to demonstrate how the remedial action evaluation process can be improved and expedited through use of the CAE system. The CAE system capabilities include the production of containment concentration maps, geologic cross-sections, water table maps, and calculation of containment volume. Several site studies have been completed for the regional offices, including the Queen City Farms

Superfund site and adjoining Cedar Hill Landfill in Seattle, Washington, and a soil gas survey in Croydon, Pennsylvania.

EVALUATION OF SOLIDIFICATION/STABILIZATION TREATABILITY STUDIES AT THE U.S. EPA CENTER HILL FACILITY

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Solidification/stabilization is being considered as either a treatment or post-treatment option for several uncontrolled hazardous waste sites containing contaminated soil. The up front prediction of the feasibility of this treatment process is complicated because of the many possible chemical interactions between the soil, site contaminant, and binder. RREL has been active in performing solidification/stabilization treatability studies at the Center Hill Facility as well as reviewing treatability studies from other sources. The following general technical issue areas have been common in the studies evaluated:

- Feasibility of stabilizing organic waste
- Long-term durability testing
- Placeability of material
- Volatile emissions during mixing and curing
- Ability to mix in field
- Construction quality assurance

A preliminary testing evaluation process has been developed for determining the feasibility of a solidification/stabilization process for a contaminated soil. Results of the treatability studies reviewed have been favorable for certain contaminated matrices and less favorable for others.

THE EPA MANUAL FOR WASTE MINIMIZATION OPPORTUNITY ASSESSMENTS

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A waste minimization assessment (WMA) is a systematic planned procedure with the objective of identifying ways to reduce or eliminate waste. The assessment consists of a careful review of a plant's operations and waste streams, and the selection of specific areas to assess. After a

specific waste stream or area is established as the WMA focus, a number of options with the potential to minimize waste are developed and screened. The technical and economic feasibility of the selected options is then evaluated. Finally, the most promising options are selected for implementation.

Waste minimization is fast gaining recognition as a means of contending with the nation's hazardous waste problem and other forms of environmental pollution. Opportunities exist for waste minimization throughout industry and government. The waste minimization assessment procedure described in the manual offers a means of determining a facility's waste situation and identifying and evaluating potential viable options for reducing waste.

The waste minimization assessment offers opportunities to reduce operating costs, reduce potential liability, and improve the environment, while improving regulatory compliance. The WMA results in a careful review of a plant's operations toward reducing wastes.

U.S. ENVIRONMENTAL PROTECTION AGENCY COMBUSTION RESEARCH FACILITY

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During FY '88, 26 weeks of incineration testing, in which 58 incinerator tests were completed, took place at the EPA Combustion Research Facility in Jefferson, Arkansas. Test programs completed included: extended demonstration tests of the American Combustion, Inc., Pyretron Thermal Destruction System under the Superfund Innovative Technology Evaluation (SITE) program; tests to evaluate the use of SF_6 injection as a surrogate destruction and removal efficiency surrogate in liquid injection incineration; an extended evaluation of the fate of hazardous constituent trace metals fed to the rotary kiln incineration system; and tests to evaluate the valence state of chromium discharges from the rotary kiln incinerator. In addition, reports for several FY '87 test programs were issued, several facility upgrade efforts were completed, and preparation for a major facility reconstruction was initiated. The presentation briefly describes several of the above program efforts.

EVALUATING THE COST EFFECTIVENESS OF SITE DEMONSTRATIONS

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The Agency's Superfund Innovative Technology Evaluation (SITE) program is designed to develop reliable performance and cost data on unique commercially available hazardous waste destruction and treatment technologies. A major challenge facing the SITE program is to insure that the cost information is developed and presented so that it can be effectively used in the Superfund decision making process. Toward this end, broad objectives were established to guide project managers in the development of cost data. The goals of the SITE program's cost analysis are:

1) To provide the public with both the developer's and the Agency's cost estimate based on well defined and appropriate operating scenarios.

2) To identify, highlight, and analyze those key operating parameters which the Agency feels are likely to have significant impacts on costs.

3) To insure that the public has the ability, if necessary, to reconstruct the Agency's cost analysis, recalculating the estimates by substituting assumptions more consistent with their situation. This means that all assumptions must be clearly stated and all equations clearly presented.

This poster will review how the SITE program has organized itself to facilitate the attainment of these goals. An approach will be presented which segregates costs into one of 12 categories. The method is akin to traditional cost engineering analysis, but these cost categories represent the typical costs which are likely to occur. This approach will facilitate cross-comparisons between SITE technologies.

SIMULTANEOUS HAZARDOUS WASTE DESTRUCTION AND TRACE METAL CAPTURE IN A FLUIDIZED BED INCINERATOR

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The Combustion Research Branch of the EPA's Air and Energy Engineering Research Laboratory (AEERL) is conducting a research project to study trace metal retention during thermal destruction of hazardous waste in a Dual-Bed Fluidized Bed Incinerator System. This abstract describes the preliminary results obtained during the initial test operation of this new

facility. The dual-bed system permits two operating conditions to be established for optimizing both oxidation of combustibles and capture of trace inorganic elements. Research is concentrating on both the Principal Organic Hazardous Constituents (POHCs) of the simulated waste feed, and the Products of Incomplete Combustion (PICs) produced by the system.

Lead chromate (PbC_rO_4) paint pigment mixed in mineral spirits and/or #2 fuel oil is burned in the first fluidized bed with sodium carbonate added as a surface flux to enhance encapsulation of the two metals into a glass structure on the surface of the silica sand particles. The second bed acts as a higher temperature afterburner to destroy any combustibles not oxidized in the first stage. Lead chromate comprises up to two percent (weight) of the fuel mixture and is injected up to a maximum rate of 1.2 pounds per eight-hour day. A material balance for the two metal elements is performed for each test to determine their distribution between the beds, cyclones, and final filter. Standard leach testing of the bed material will determine the retention potential of the bed material for these two metals. Temperature and velocity variation effects on capture are being determined by this test series. The following test series will study the effects of halogen presence on metals capture and will lead into studies of organic halogen compound destruction.

BIOTROL SOIL WASHING SYSTEM

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BioTrol, Inc. has developed an on-site treatment system for the remediation of contaminated soils from wood preserving sites. The system is based on a series of intensive scrubbing and physical separation steps using water as a carrier for the soil and contaminants. Contaminant removal efficiencies of 90 to 95 percent have been achieved. Process water from the system is treated in a fixed-film bioreactor using an amended bacterial consortium prior to recycle back to the soil scrubbing system. This paper presents the results of two phases of pilot testing recently completed at a wood preserving site in Minnesota using a mobile, 500 lb/hr pilot-scale unit.

SEPARATION OF HAZARDOUS ORGANICS BY LOW PRESSURE REVERSE OSMOSIS (RO) MEMBRANES

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Membrane processes are gaining considerable attention for the separation of organics and inorganics from hazardous wastes. Membrane processes can be divided into four categories: high pressure RO, low pressure RO, nanofiltration, and ultrafiltration. Low pressure processes with thin-film composite membranes have definite advantages in terms of energy savings and capital cost. Extensive experiments were conducted with two types of aromatic polyamide membranes. The presentation will include: (1) membrane selection criteria, (2) selective separation of ionizable organics, and (3) combination ozonation-membrane process for the removal of chlorinated hazardous organics.

Membrane experiments were carried out with various priority organic pollutants with and without partial ozonation. Partial ozonation converts many chlorinated organics to intermediate organic acids. These ionizable intermediates were effectively removed by charged and uncharged membranes without a significant drop in water flux. Charged reverse osmosis membranes provide additional advantages because high water flux (11×10^{4} cm/s) can be obtained even at low pressures.

TESTING OF A LEACHATE TREATMENT SYSTEM BASED ON A WOOD DEGRADING FUNGUS

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The fungus, Phanerochaete chrysosporium, has been employed in the design of a rotating disk reactor for liquid treatment. Early studies decolorizing Kraft waste liquor were very promising, and subsequent applications to individual hazardous waste constituents such as pentachlorophenol and trinitrotoluene were equally impressive. The latter application to hazardous waste has become the subject of an intensive study to scale-up the early bench-scale reactors. The research program and status will be presented with details of projected field activities.

ASSESSMENT OF KPEG TREATMENT FOR PCB CONTAMINATED SOILS

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The KPEG reagent (potassium polyethylene glycolate) has successfully demonstrated its effectiveness on PCB contaminated soil in Guam, during two trial periods in 1988. A modified Littleford reactor system capable of containing from one to one and three quarters tons of contaminated material was employed as the pilot plant for this treatment. Treatment times varied from four to eight hours depending on contamination level, water content, and quantity of material. PCB levels in the contaminated soil varied from a few hundred to several thousand ppm. After treatment, PCB residuals were reduced to below 2 ppm.

The first treatments of eight contaminated soil batches of one to one and three quarters ton each were accomplished during April to May 1988. Aroclor levels were reduced from 1,000 to 2,000 ppm to less than 2 ppm in four of the eight batches. Residual levels in the other four batches were between 3 to 16 ppm.

After an assessment of the original treatment, a return to Guam was scheduled for September to October 1988, for the purpose of retreatment of the four batches having greater than 2 ppm of residual PCBs, and to demonstrate the capability of the improved decontamination system. This was demonstrated in treatment of three contaminated soil batches by lowering residual PCB congeners to below 2 ppm. Further, the system was used to decontaminate a batch of Tyvek® clothing, boots, and personal protective gear. This was also successful.

METHODS FOR MEASURING SOIL LINER VAC PERMEABILITY IN THE FIELD

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The Congressionally mandated performance standard for soil liners of hazardous waste management facilities is a hydraulic conductivity of 1 x 10^{-9} meters/second (m/s) or less. In response to this statutory requirement, the U.S. Environmental Protection Agency has issued guidance requiring that facilities demonstrate this hydraulic conductivity in field tests.

Hydraulic conductivity test methods currently used on soil liners were evaluated for their ability to meet the minimum requirements for field tests. These requirements are that the test be capable of measuring hydraulic conductivities as low as 1×10^{-9} m/s, and that the values obtained be representative of the overall soil liner. Of the few methods capable of meeting the minimum requirements, even fewer are both practical to use and rarely give false low values. Considering all the advantages of the methods evaluated, the best, most practical, and currently available technologies for evaluating hydraulic conductivity are represented by large single-ring infiltrometers and sealed double-ring infiltrometers. If correction factors are needed to bring the values obtained with single-ring devices below 1×10^{-9} m/s, confirming tests should be conducted with sealed double-ring infiltrometers.

A long-term study is needed to allow comparative evaluation of candidate hydraulic conductivity testing devices. A large underdrain should be incorporated into the study to give the true overall hydraulic conductivity value to which other values should be compared.

REVIEW OF SOIL WASHING TECHNOLOGIES FOR SOILS CONTAMINATED WITH HEAVY METALS

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Heavy metals are estimated to contaminate 40 percent of the Superfund sites on the National Priorities List (NPL). Studies have shown that eight metals (lead, chromium, arsenic, cadmium, copper, zinc, mercury, and nickel) predominate at these sites. These facts have led to a review of the current status of washing (extraction) technologies employed on excavated soils.

The most advanced extraction technologies are identified and their basic processing steps discussed. A review is presented of the mature industrial practices incorporated within the technologies for cleaning soils, sludges, and sediments. The results reported by those that have developed and operate facilities employing these technologies are discussed as are some of the apparent limitations inherent in their application. An assessment is made on where to go from here on the further development of extraction technologies for excavated soils.

ROTARY KILN INCINERATION

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A multifaceted experimental and theoretical program aimed at understanding rotary kiln incinerator performance is underway. The program involves university, industry, and government participation. This paper will summarize work accomplished to date in the areas of full-scale in-situ sampling from an operating rotary kiln facility, kiln-simulator experimentation, and numerical modeling.

Full-scale in-situ measurements are obtained from the Louisiana Division rotary kiln facility of Dow Chemical USA, located in Plaquemine, Louisiana. We will present summary results obtained from experiments that were performed during continuous processing of carbon tetrachloride and preliminary results obtained during the batch mode processing of toluene-laden sorbent packs. The information is needed to develop reasonable mathematical models of the process for use in incinerator evaluation and incinerator design. Our results to date demonstrate the existence of significant spatial and temporal variations in temperature and species concentrations in the kiln even under quasi-steady operating conditions. The addition of turbulent air (to promote mixing) reduces, but does not eliminate, these variations. A consequence of the enhanced mixing, however, appears to be a reduction in processing rates in the upper regions of the kiln and an increase in the demand on the afterburner. Data obtained from the kiln/afterburner/stack train will be presented to demonstrate these trends.

Kiln simulator work conducted during this study has aided in providing an understanding of the results observed at the full-scale. An objective of the laboratory kiln simulation work has been to determine bed evolution rates. Our results clearly demonstrate the utility of the kiln-simulator in helping to understand processes occurring at the full-scale. The importance of kiln rotation rate (hence, bed motion) on the evolution characteristics of the studied sorbent-contaminant matrix has been demonstrated. The intermittence in contaminant evolution observed at the full-scale has been, at least in part, explained through careful interpretation at the kiln-simulator scale.

BIOLOGICAL TREATMENT OF CHLOROPHENOL-CONTAMINATED GROUNDWATER

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BioTrol, Inc. has developed a system for the treatment of chlorinated phenols in wastewater streams. The phenols are degraded by microorganisms which are immobilized in a submerged, fixed-film bioreactor. An indigenous consortium of microorganisms is augmented by inoculation of a specific bacterium with capability to degrade penta-chlorophenol (PCP) as well as tetra- and tri-chlorophenol. BioTrol has demonstrated treatment of wastewater containing up to 90 ppm PCP. Removals from 95 to 99 percent were achieved with a one-hour hydraulic residence time. The system is primarily applicable to treatment of groundwater; however, treatment of process and lagoon waters has also been demonstrated.

COMPUTERIZED MANAGEMENT AND DISSEMINATION OF INFORMATION FOR RESEARCH AND DEVELOPMENT OPERATIONS AT THE TECHNICAL INFORMATION EXCHANGE (TIX), EDISON, NJ

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The Technical Information Exchange (TIX) at EPA's Edison, New Jersey Facility was established in 1980 to support the research personnel at this location. It is operated by a Research and Development (R&D) on-site contractor, currently Enviresponse, Inc., for EPA's Releases Control Branch (RCB) of the Risk Reduction Engineering Laboratoy (RREL).

TIX provides a wide range of support services for RREL research activities being conducted at the Edison Facility, including the preparation of slides; selection of slides, movies, and videotapes from the extensive library developed by RCB over the years for presentation; and dissemination of descriptive literature. TIX provides immediate access to its collection and assists in locating or procuring materials from other sources (e.g., EPA's Center for Environmental Research Information, other Agency information sources, the National Technical Information Service, etc.). A library of

commercial software is maintained so users may evaluate various packages before purchasing additional copies.

TIX also pursues research studies of its own into the computerized retrieval and dissemination of this information. It developed and maintains the Computerized On-Line Information Service (COLIS) designed to meet the needs of several specific R&D efforts. COLIS searches by key words to retrieve files for display. While COLIS is expandable to other needs as they arise, the intent is not to compete with broad-based, commercial types of information data bases. Currently, while not all tasks are equally advanced in their development, COLIS is designed to service program efforts.

TREATABILITY DATA BASE

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During the past year, the Risk Reduction Engineering Laboratory (which now includes the former Water Engineering Research Laboratory) has developed and is continuing to expand a data base on the treatability of chemicals in various types of waters and wastewaters. This activity is being conducted under the direction of Kenneth A. Dostal.

The data base currently covers 395 chemicals with 1,500 sets of treatability data for 194 compounds. Thus far, emphasis has been placed upon the priority pollutant list, Appendix VIII of RCRA, and those compounds being found at Superfund sites. Initially, most of the data has been for organic pollutants; more effort is being placed on metals and other inorganics this fiscal year.

Copies of the data base are being distributed by the author in the form of PC discs to those who request a copy. All that is required to use the data base is an IBM PC compatible with 640K memory – no special PC program is necessary.

CHEMICAL TREATMENT OF METALS IN WASTEWATERS AND SLUDGES AT THE T&E FACILITY

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Hazardous waste treatment technology studies are currently being conducted at the U.S. EPA's Test and Evaluation (T&E) facility. As a part of this program, alternative technologies are being evaluated for the treatment of hazardous wastes containing heavy metals and cyanide. Both bench- and pilot-scale research studies are being performed to evaluate the removal of cyanide from spent electroplating solutions and residues. Findings to date have shown that it is important to destroy all forms of cyanide (amenable, non-amenable, and complexed) in cyanide/metal bearing wastewater prior to metals precipitation. Otherwise, significant quantities of cyanide (complexed) can be precipitated with heavy metals into a hydroxide sludge. Although conventional alkaline chlorination is a widely employed technology used to destroy amenable (free) cyanide in solution, often strongly complexed (non-amenable) cyanides remain in solution impervious to chemical oxidation. Several processes have shown potential for breaking these complexes (e.g., ferricyanide) and destroying the cyanide. Ozonation/photolysis (UV light) is one of them. Bench studies will be conducted evaluating this technology. In the area of metals treatment, work will be performed which will evaluate the treatment of an EDTA-lead complexed wash generated from the treatment of lead-contaminated soils. Additional studies will focus on the treatment of chromate wastes resulting from tanning, wood-treating, and ink manufacturing operations. Results generated from these studies will be presented.

BIOLOGICAL DEGRADATION OF CHLORINATED PHENOXYACETATES AND PHENOLS

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Previous studies have shown that Pseudomonas cepacia strain AC1100 and Alcaligenes eutrophus strain JMP134(pJP4) metabolize the chlorophenoxyacetate herbicides 2,4,5-T and 2,4-D, respectively. Our results indicate, however, that both of these activities are inhibited when co-cultures of the two organisms are confronted with mixtures of 2,4,5-T and 2,4-D. The basis for this inhibition may be related to the physical separation under these conditions of the 2,4,5-T degradative activity in AC1100 from the 2,4-D degradative activity in JMP134(pJP4) since we have shown that the effect can be largely eliminated by transfer of the 2,4-D degradative genes (via pJP4) from JMP134 to AC1100. Further studies on the chemical and/or physiological basis for this inhibition are currently in progress. Studies are also being initiated to determine the chlorophenoxyacetate and chlorophenol degradative activities of AC1100(pJP4) both alone and in conjunction with KPEG pretreatment in various environmental samples such as soils and surface waters. Potentially limiting factors that will be evaluated will include nutrient requirements, KPEG toxicity or inhibition, toxicity or inhibition by other compounds, matrix effects (in soils), and interactions with indigenous microorganisms.

USE OF FOAM TECHNOLOGY FOR CONTROL OF TOXIC FUMES DURING EXCAVATION AT SUPERFUND SITES

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In the wake of the Bhopal disaster, there is increasing public and governmental concern over the possibility of toxic gas and vapor releases from chemical plants. Industry is under intense pressure to provide additional safeguards to prevent gas clouds from threatening populated areas.

Many ways to prevent releases are already in use by industry, ranging from safety-conscious plant design, through safety alarms and interlocks, to backup devices such as scrubbers and flares. However, once a gas leak occurs, the options for its control are few.

Under study is the use of foam scrubbing as a new option for controlling emergency releases. Foam is to be generated from a concentrated fluid that contains neutralizing agents. Once the bubbles are formed, a large interior liquid surface area is available for gas, vapor, or particulate absorption. A neutralization agent present in the bubble walls then can react with the absorbed gas or vapor to render it innocuous.

This proposed technology can be applied to treat the toxic vapors and gases generated during excavation at Superfund sites. The fumes would be vacuum charged through high expansion foam generators and would be rendered innocuous by the neutralizing agents in the foam bubble walls.

SOIL WASHING — REMOVAL OF SEMI-VOLATILE ORGANICS VIA AQUEOUS SURFACTANT SOLUTIONS

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A process for removing semi-volatile organic chemicals from soil using aqueous surfactant solutions as the extracting medium and high mass transfer rate ultrasonic cavitational excitation for liquid-solid contacting is described. The following experimental results of tests to confirm performance of all critical processing steps are described:

- Soil deagglomeration and clay separation
- Ultrasonic cavitational extraction
- Spent wash solution — philic to phobic conversion
- Hydrophobic organic removal.

PREPARATION FOR SITE DEMONSTRATION OF A POWDERED ACTIVATED CARBON TREATMENT (PACT) UNIT

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As part of the Superfund Innovative Technology Evaluation (SITE) program, Zimpro/Passavant Inc. will work with EPA to conduct a field demonstration of its mobile Powdered Activated Carbon Treatment (PACT) unit. The project is designed to produce data on the feasibility and cost-effectiveness of using the process for Superfund site remediation.

The PACT process is a biological treatment system which incorporates physical adsorption using powdered carbon. It is particularly well suited to the treatment of combined industrial/municipal wastes. In the PACT process, powdered activated carbon is added to the aeration basin of a standard activated sludge system at a dose rate that may vary considerably depending on the biodegradability and adsorptivity of the waste components. Carbon dosages may range from a low of 10 mg/l to more than 1,000 mg/l.

During operation of the PACT unit, excess solids (biomass and activated carbon) are removed from the system by wasting a portion of the clarifier underflow. These solids may then be dewatered and disposed or sent through a wet oxidation unit or other type of thermal processor for carbon regeneration. The SITE demonstration of the PACT system will employ wet air oxidation (WAO) to regenerate carbon and destroy organic contaminants carried with the solids.

The PACT demonstration is scheduled for start-up in the spring of 1989. During the winter of 1988 to 1989, personnel from Zimpro/Passavant and PRC Environmental Management, Inc. (the SITE support contractor for this task), conducted treatability studies on wastewater collected from the demonstration site. These data will enable design of the treatment protocol for the full-scale field demonstration.

NOTES

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